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Tin droplets for LPP EUV sources

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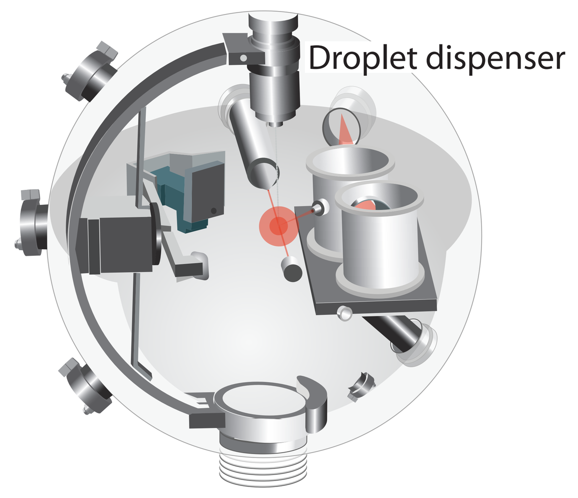
Introduction

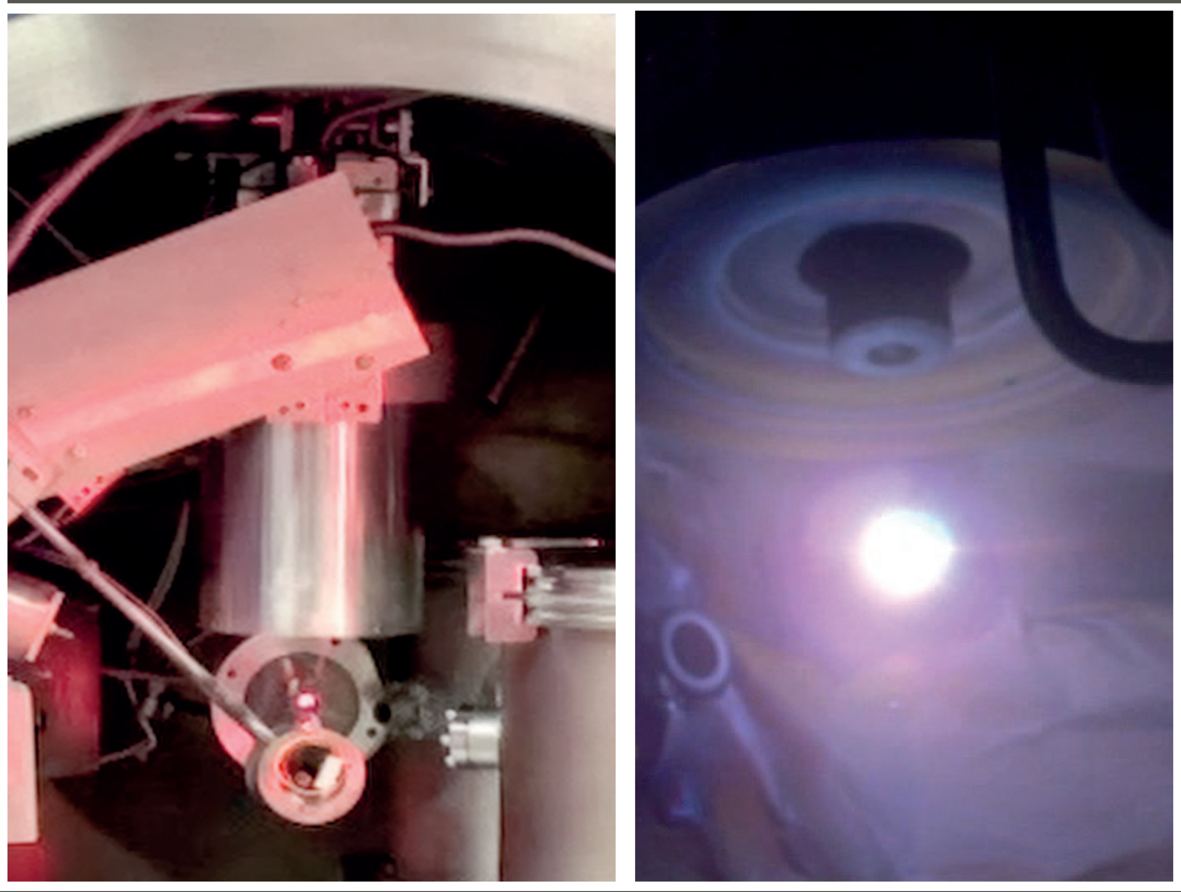


ETH Zurich/ LEC is developing a reliable, cost-effective and high brightness EUV source for metrology and for high volume manufacturing application. The EUV target is a high frequency tin droplet combined with an industry proven high power Nd:YAG laser which can deliver up to 1.6 kW of power at short pulse. A state-of-the-art debris mitigation system protects the EUV collection optics.

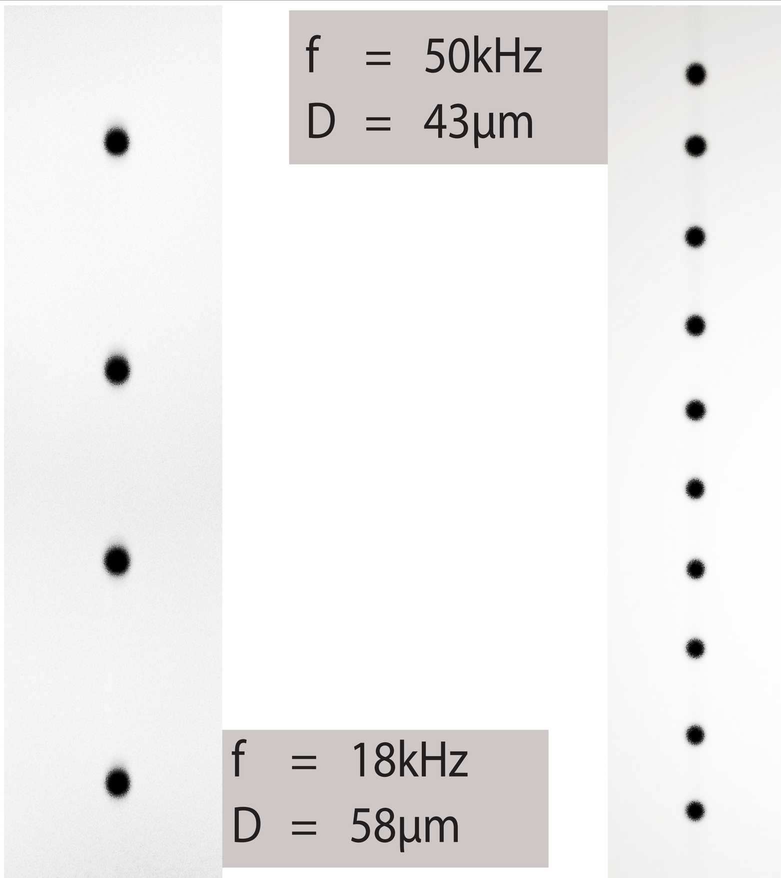
Droplet generator is a key component of LPP EUV sources:

- Droplets are a regenerative target and are synchronized with pulsed lasers
- Neutral debris and residual target material can be controlled by droplet size
- Source stability directly correlates with the stability of the fuel delivery system

Droplet Dispenser



Droplet Visualization



Droplet Modeling

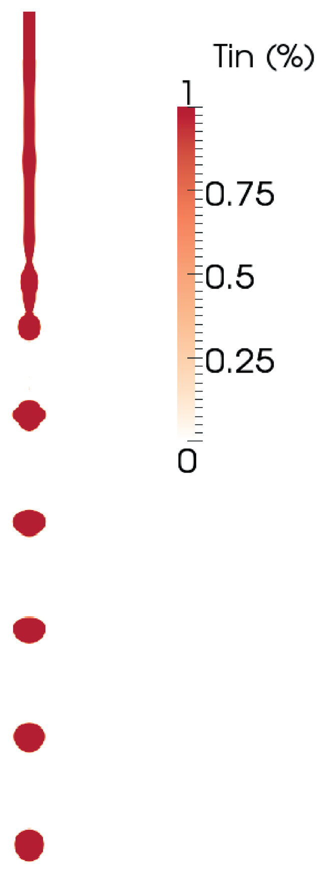
Single droplet visualization using macroscopic lens, high speed camera and strobe at the laser irradiation site.

Droplets are generated by Rayleigh breakup of a liquid tin jet.

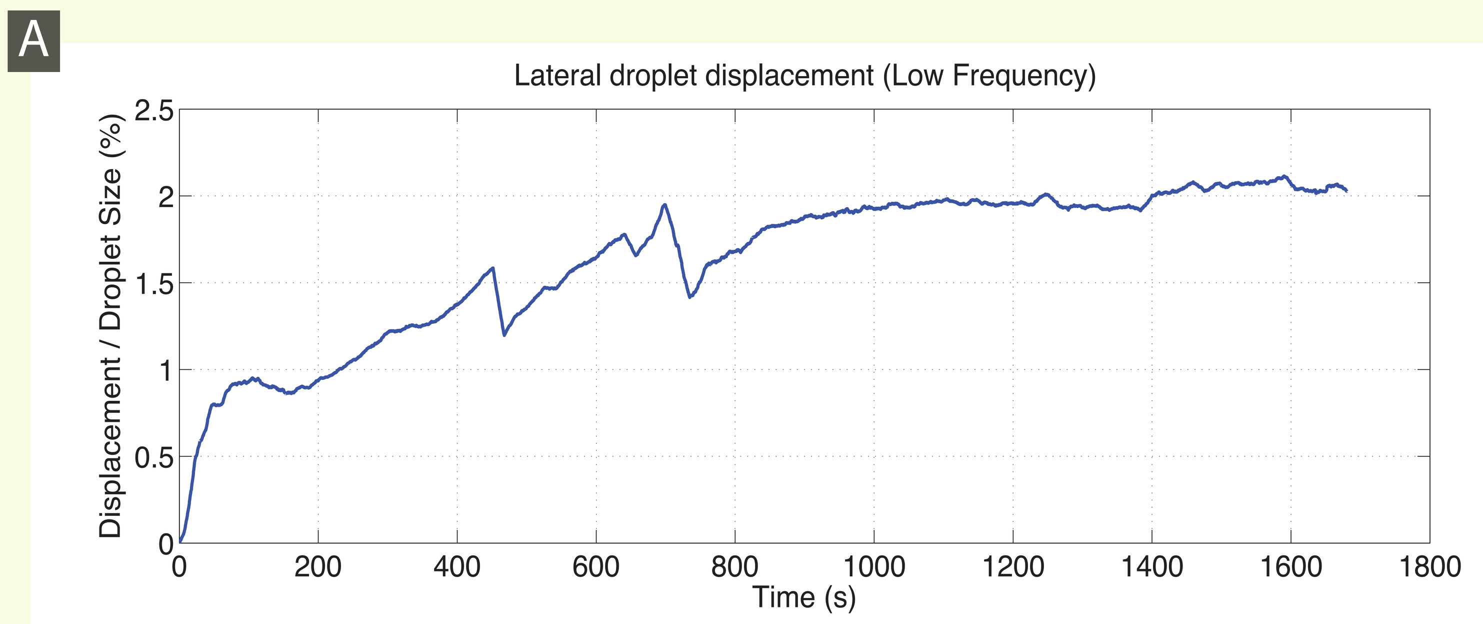
Droplet generator development is supported by experimentally validated computational simulations of droplet formation.

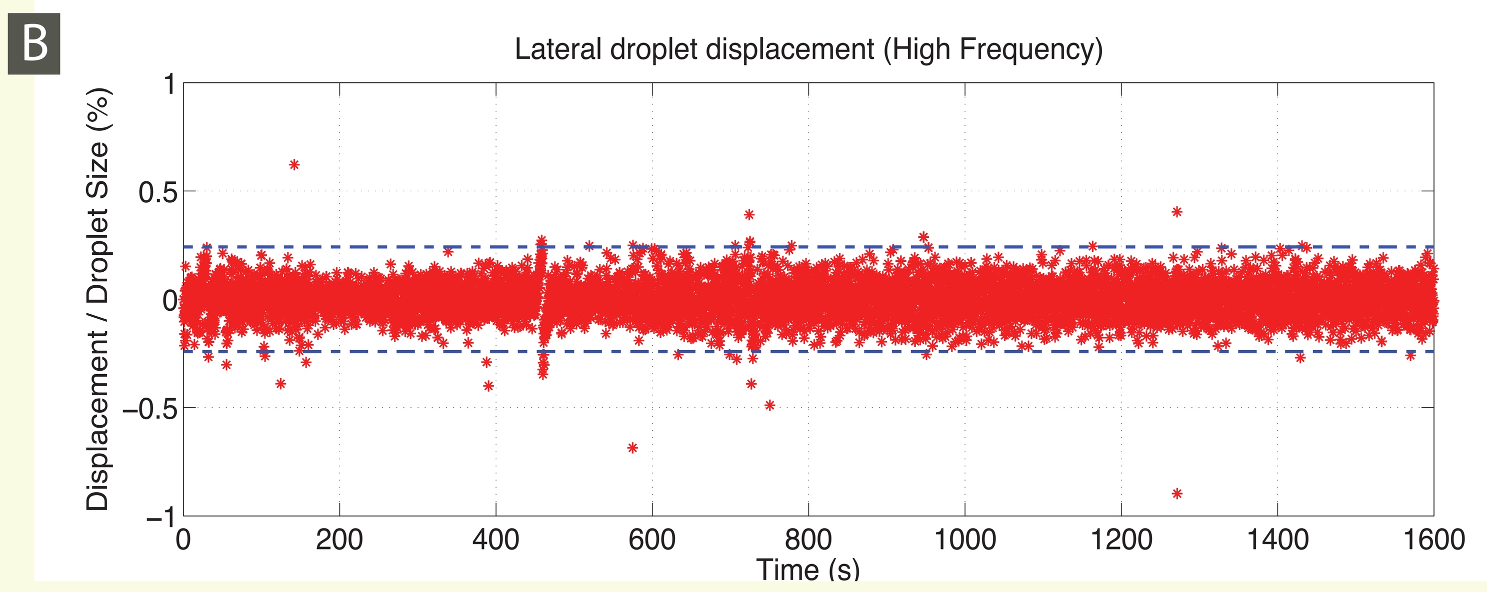
100 kHz droplet validation

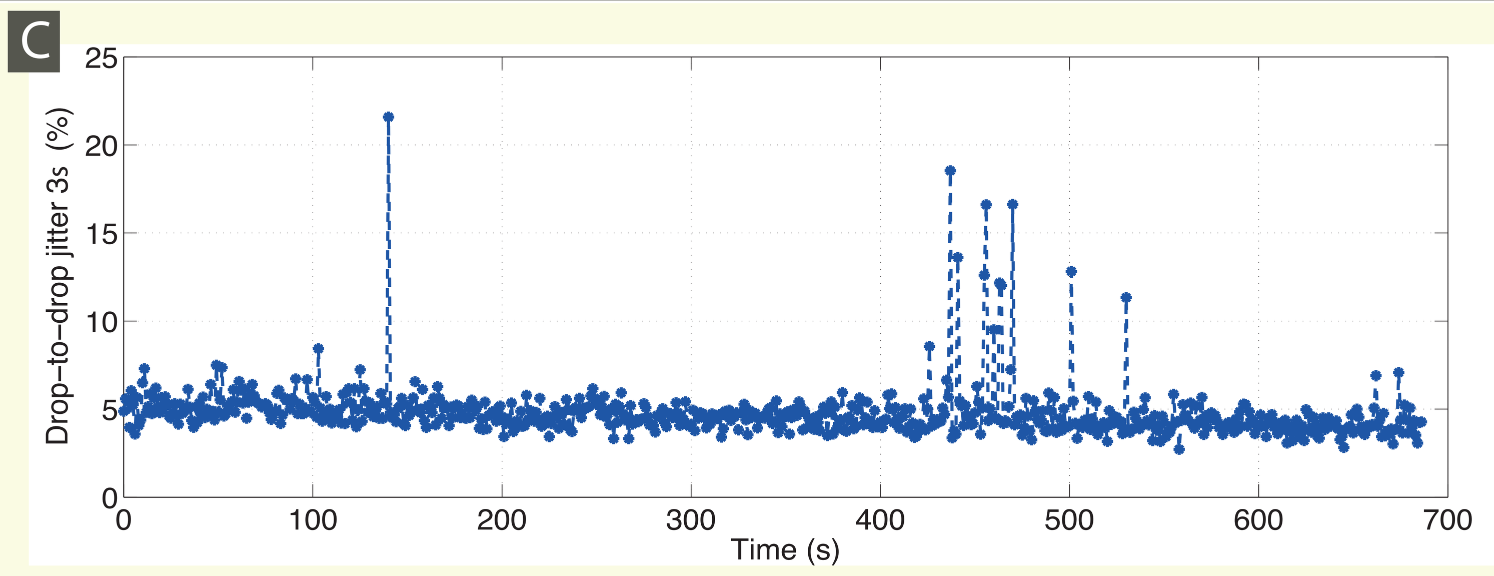
	Experiment	Simulation	Dev
Diameter	38um	43um	13%
Velocity	12.1m/s	11.1m/s	9%



Droplet Stability



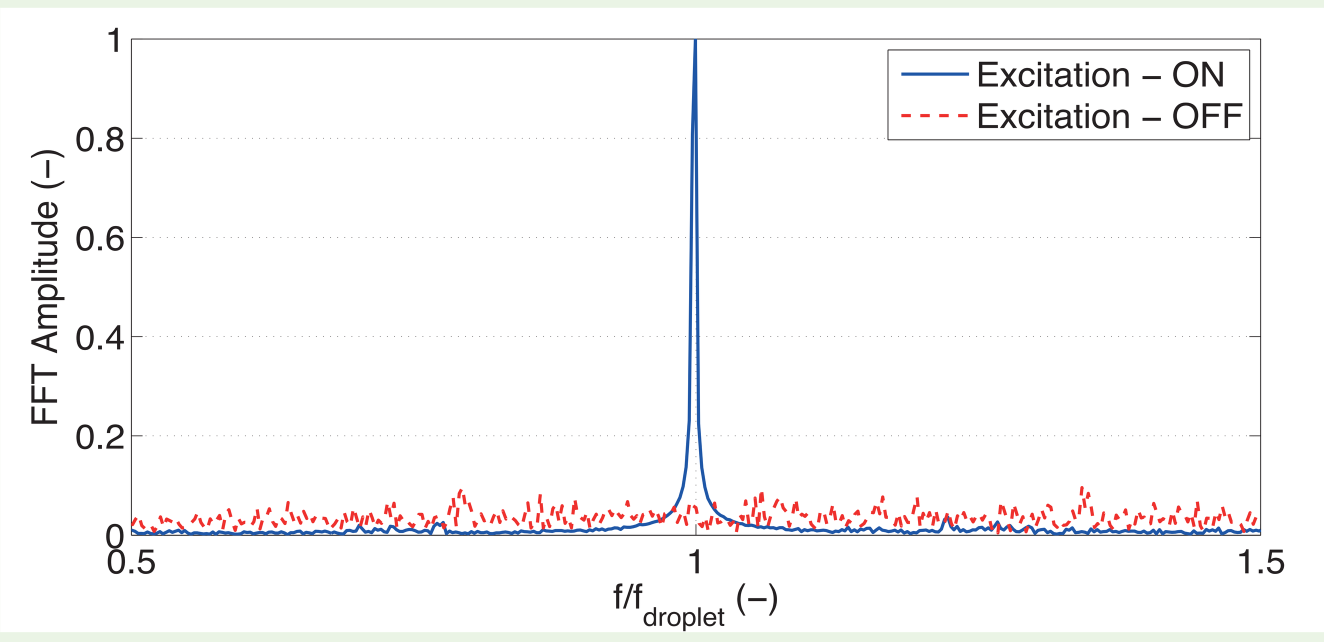




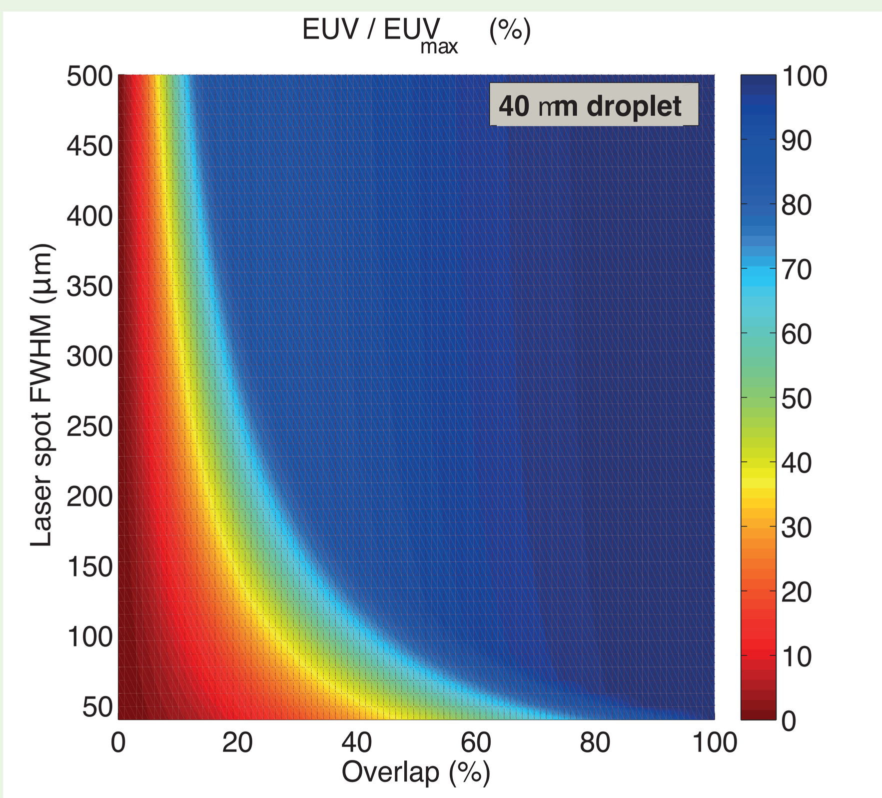
Lateral (along droplet train) displacements imply variations in the deposited laser energy. The results are derived from droplet imaging.
(A) Low frequency content (Hz scale) of lateral displacement
(B) High frequency content (kHz scale) of lateral displacement

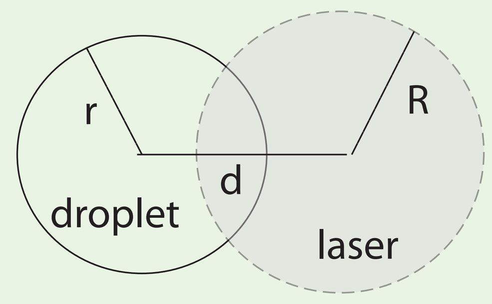
(C) Drop-to-drop jitter leads to laser pulse de-synchronization.

Both instability modes induce variations in EUV emission.



Droplet frequency (blue) imposed on natural breakup (red) by piezoelectric transducer.





overlap= 1-d/(r+R)

Misalignments between laser spot FWHM and droplet lead to a decrease in emitted EUV. An increased laser spot enlarges emission stability. The droplet diameter in this study is 40µm.

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